

Beyond Rigid Body

Integrated Structural Control of Extremely Lightweight Flexible Aircraft

Why?

Reduced weight is fundamental to aerospace design

Many years of aerospace development has resulted in extremely efficient lightweight structures

Advancement now requires a new paradigm

- Retain strength but allow for reduced stiffness
- Provide apparent stiffness with integrated active structural control

Side Benefit: Advancement of full-authority adaptive flight control for realistic full-scale vehicles will not proceed until methods for sensing and accounting for structural limitations are developed

Development Areas

Modeling

- High order models with structural interactions and unsteady aerodynamic effects required
- MDAO elastically tailored structures

Sensors

- Fiber Optic Shape Sensing (FOSS)
- Fly-by-feel (hot films and beyond)
- Others ...

Actuation

- Potentially very high bandwidth requirements
- Piezoelectric, mems, others ...

Control Algorithms

- Balance structural shape, structural load, dynamic interaction suppression, with rigid body performance requirements

X-56A Multi-Utility Technology Testbed (MUTT)

AFRL funded

Designed & Built by Lockheed Martin Skunk Works®

Complete Research System

- 2 Center Bodies
- 1 Stiff Wing Set
- 3 Flexible Wing Sets
- 1 Ground Control Station
- With Simulation and SIL Capabilities

Conclusions

Integrated structural control will enable breakthroughs

- New class of extremely lightweight vehicles
- Advance feasibility of full authority adaptive flight control

The X-56A MUTT vehicle provides an excellent tool to explore this technology

References

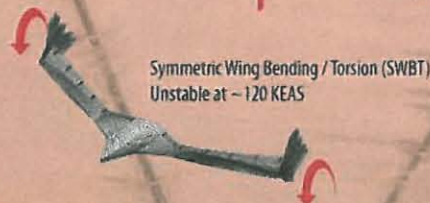
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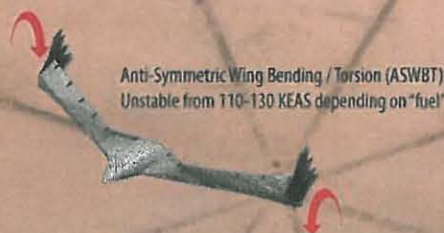
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Body Freedom Flutter (BFF)
Unstable at ~80 KEAS



Symmetric Wing Bending / Torsion (SWBT)
Unstable at ~120 KEAS



Anti-Symmetric Wing Bending / Torsion (ASWBT)
Unstable from 110-130 KEAS depending on "fuel"

X-56A

Multi-utility Aeroelastic Demonstrator

Removing the Flutter Barrier